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Owens College.

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Report x x x on the Science

Schools of Germany

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January 1869.



Science

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## OWENS COLLEGE EXTENSION.

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## REPORT TO EXTENSION COMMITTEE.

In accordance with the instructions of the Committee we visited, in the course of July, the following Universities and High Schools of Science:—Bonn, Göttingen, Hanover, Berlin, Leipzig, Freiberg, Heidelberg, Carlsruhe, Munich, and Zürich. Buildings and Museums were everywhere thrown open to us with the utmost readiness, and our inquiries were freely answered. We prosecuted the task confided to us in as great detail as was allowed by the necessity of completing our circuit by the end of July; and we beg leave to offer to the Committee the following report of the results of our mission, premising (1) that our inquiry was chiefly, but not exclusively, directed to the Science Departments of the Universities and Schools visited; and (2) that in this Report we have thought it sufficient to give a full account of one or two only of these schools—such as seemed to us the most typical; much of the matter collected by us, both as to schemes of study and as to buildings, being reserved for the use of the Committee, as they proceed with the details of their task.

We propose to arrange our report under the following heads:—

- I. The amount and kind of teaching power provided in the Science Department of the Universities and Schools inspected by us.
- II. The provision made, *a.* for the payment of the Professors; *b.* for the payment of the Assistants; *c.* for the maintenance and augmentation of Apparatus and Collections.
- III. Plans of Buildings, &c., and their cost.
- IV. Rules of Studentship in respect of age, preliminary attainments, and length of study.
- V. Relations existing between Universities proper, and Polytechnic Institutions; and again, between these, on the one hand, and schools, whether *Gymnasias* or *Real-Schulen*, on the other. The attitude of the scientific towards the old classical culture.
- VI. Relations existing between State Governments and Academical Bodies.
- VII. *Seminaria*, &c.
- VIII. Conclusions.

I. *The amount and kind of teaching power provided in the Science Department of Universities and Schools visited.*

The first fact which impresses the English observer of German Universities under this head is this—that the number of teachers, both of the first and second grade, is considerably greater than in English Universities and Colleges, even after account has been taken of the larger number of students. And this discrepancy is, perhaps, greatest in the Science Departments. Provision is thus made both for the effective instruction of students, and for the zealous prosecution of original research. It is in this fixed union of teaching with independent research that Prof. von Sybel, the Rector of the University of Bonn, in his eloquent lecture “on German and Foreign Universities,” finds the special excellence of the German Universities to consist. The combination is cherished, not only with a view to the advancement of science, but because by this union in one body of students, teachers, and discoverers, a *school* is made, students are drawn from a wider area as to an acknowledged centre of intellectual action, and an *esprit de corps* is created, which reacts with incredible effect on the energies of teachers and learners alike.

**BONN.**—We begin with Bonn. In the University of Bonn there are two Professors of Chemistry, Kekulé and Landolt, who are respectively Ober-Director and Director of the newly-erected Chemical Institute; and under these are five skilled assistants—one for Organic Chemistry, one for Qualitative and one for Quantitative Analysis, one for the Lecture-room, and one a sort of Supernumerary. Again, Professor Bischof is Director of the Chemical Laboratory and Technological Cabinet. There are, besides, Directors of the Pharmaceutical Laboratory and Apparatus, and probably other officers in this department.



The department of *Physics* does not appear to be now in a thriving state at Bonn, owing, probably, to the recent death of Prof. Plücker. The directorate of the department, with its cabinets, is vacant.

In the *Natural History* Department we find two Professors, who are also Directors of the Natural History Museum. The Museum also possesses a Curator of the *Palaeontological* Collection, who, at the same time, is an authorized lecturer on his subjects. Attached to the *Botanical Garden* and *Institute* are a Professor, an Inspector, and an Assistant. No account is here taken of the Anatomical and Physiological Professors, who are included in the Faculty of Medicine.

Of *Astronomy* there is one Professor, Dr. Argelander, who is also Director of the Observatory; he has one skilled assistant.

In the Department of Chemistry, we are able to make a comparison with the provision existing in Owens College, in a ratio with the number of students taught. There are about 90 students in Professor Kekulé's largest class, and in the three Laboratories is room for 60 workers, though these 60 places are not all filled. At Owens College, last session, there were 76 students in the largest class, and 44 workers in the Laboratory; and our staff consists of one Professor and one Assistant.

The total number of students at Bonn in the Philosophical Faculty (Faculty of Arts), for the summer half-year of 1868, was 275; the number of Ordinary Professors was 27; of Extraordinary Professors, 11; and of Authorized Private Teachers (Lecturers), 19.

**GÖTTINGEN.**—In Göttingen *Chemistry* is (against the usage in Germany) attached to the Medical Faculty; there are, however, three divisions—the General, the Physiological, and the Agricultural. In the first, we found Professor Wöhler, with four skilled Assistants; two of these being also Professors. In the Physiological division is another Professor, with one Assistant: and in the Agricultural division, is one Professor and one Assistant. There are, further, four Laboratory servants.

Prof. Wöhler delivers the principal course of lectures on Systematic Chemistry. His Assistants lecture on special branches. The whole staff directs the Laboratory; and over and above these are the two Professors of Physiological and Agricultural Chemistry, who conduct their own Laboratories.

In *Physics*, Professor Weber and his Assistants, Professors Listing and Kohlrausch, conduct an excellent *Physical Laboratory*, and lecture on the several branches of *Physics*—Systematic Physics, Optics, Electricity, &c., Light and Heat, Meteorology. Prof. Ulrich treats of Hydrostatics and Hydraulics.

In *Natural History*, Professor Keferstein lectures on *Comparative Anatomy*, and performs zootomical demonstrations in the Zoological Museum during eight hours weekly to the students; for four hours weekly the Museum is open to the public, when the same Professor is present to conduct demonstrations. Two Professors lecture on *Botany* (each six hours weekly), and combine with their lectures excursions and demonstrations in the Botanical Garden; there is also a third assistant Professor. Professors Sartorius von Waltershausen and von Seebach lecture each four or five hours weekly on *Mineralogy* and *Geology*, and conduct practical demonstrations in the Museums.

Professor Klinkerfues lectures on *Astronomy*, theoretical and practical.

We have given this minute analysis of the provision made at Göttingen for the study of the sciences of observation and experiment, as the routine of any one of the leading universities serves to illustrate the method adopted in Germany. Göttingen, it will be remembered, is not one of the more recently-founded Universities, nor is it in any special degree subject to the influences which have so remarkably fostered the growth of the branch of education under consideration.

**BERLIN.**—Of Berlin University it will be enough to say that in *Chemistry* four Professors and five other lecturers give 20 distinct courses—theoretical and practical—among which, in addition to several distinct courses on Systematic Chemistry, are included such subjects as the History of Chemistry, the Chemical Foundations of Geology, Metallurgy, and Pharmacy.

Under the head of *Physics*, the following distinct courses were given in the summer half-year of 1868:

Experimental Physics,	...	...	...	...	...	...	4 hours weekly
Technology,	...	...	...	...	...	...	5 " "
Acoustics,	...	...	...	...	...	...	4 " "
Capillary Theory,	...	...	...	...	...	...	2 " "
Theory of Light and Optical Instruments,	...	...	...	...	...	...	2 " "
Physiological Optics,	...	...	...	...	...	...	4 " "
Mechanical Theory of Heat,	...	...	...	...	...	...	1 " "
Hydrography	...	...	...	...	...	...	1 " "
Physical Geography, Theoretical and Practical...	...	...	...	...	...	...	2 " "
Instruction in the Method of Making Geographical and Physical	...	...	...	...	...	...	3 " "
Observations,	...	...	...	...	...	...	3 " "

These 10 courses are given by seven Professors; and a Physical Laboratory is conducted by Professor Magnus.



In *Natural History* ten Professors and lecturers gave 21 courses, theoretical and practical. It will complete this analysis of the courses given in the University of Berlin in the summer semester of 1867-8, if we add that:

In *Classics* and the allied subjects, thirteen Professors and lecturers gave 23 courses; and on other ancient and on modern languages, eighteen Professors and lecturers gave 40 courses.

In *Mathematics*, six Professors and lecturers gave 13 courses.

In what we should term *Mental and Moral Philosophy*, including *Pædagogy*, eleven Professors and lecturers gave 19 courses.

In the *Economic and Agricultural Sciences*, seven Professors and lecturers gave 12 courses.

In *History and Geography*, nine Professors and lecturers gave 13 courses.

In *Belles Lettres* and the *Fine Arts*, seven Professors and lecturers gave 10 courses.

All the courses enumerated above belong to the Faculty of Arts (*Philosophische Facultät*), and are exclusive, of course, of the three other Faculties of Theology, Law and Medicine.

It is unnecessary to say that we do not set forth this list of Teachers and Lecturers as a pattern for us to follow in Owens College or in English Universities generally. We only desire to point out and emphatically to press the importance of the principle that the existence (in due proportions) of a *plurality* of teachers is an indispensable prerequisite both for breadth and depth of instruction. Where only one teacher is charged with one leading branch of study, it is barely within his power to provide the systematic teaching necessary for *pass-men*; whereas, if, as in German Universities, several teachers lecture concurrently on subdivisions of a subject, the more advanced students have the opportunity of studying more thoroughly some one section of their subject. The teachers are also induced, by the opportunity of lecturing on special subjects, to engage in profounder investigations; and thus that other aim of university institutions—the advancement of science and the promotion of a learned class—is furthered. This is a consideration, however, at least so far as England is concerned, for a remote future: it is sufficient for us to insist on the necessity of this plurality of teachers in order to really effective teaching.

The Berlin *Gewerbe-Akademie*, which corresponds to the Polytechnic Schools of Zurich and Carlsruhe, is an institution of the first magnitude. There are 520 students between the ages of 18 and 25, and a very complete staff of Professors. It is divided into 3 departments,—(1) of Mechanics, (2) of Chemistry and Metallurgy, (3) of Shipbuilding; and it is proposed to add a fourth, to be called the *Philosophical Department*, to embrace subjects appertaining to general culture, including even the “*beaux arts*.” The State allots £7,800 yearly to the support of the academy, and in addition to this large sums have been spent on the collections of models and casts, and on the very complete library.

**LEIPZIG.**—In Leipzig University the new *Laboratory* is just approaching completion, and it appeared to us to offer one of the best models, as to plan, style and cost. Provision is being made for 100 workers—60 of them beginners, and 40 more advanced students. Prof. Kolbe, the Director, will be furnished with three skilled assistants—two for the Laboratory and one for the Lecture-room—but Dr. Kolbe believes that four will, in fact, be necessary. In addition three servants will be provided.

**HEIDELBERG.**—In Heidelberg, as in Berlin, and even in a more perfect measure, large provision is made for the study of physical science. The *Physical Laboratory* conducted by Prof. Kirchhoff is very successful. Once weekly Prof. Kirchhoff lectures, with experiments, on a given subject; in the following week each student in the Laboratory goes through the experiments for himself; and in this consists the essence of the course. Students can also prosecute independent research for several hours in the week.

The *Chemical School* of Heidelberg has always been a celebrated one, and since the appointment of Bunsen to the University its renown has greatly increased. In no other European Laboratory, with the single exception of that of Liebig, at Giessen, have so many promising scientific chemists been trained, and this has been wholly due to the untiring interest shown in each student by the illustrious Professor who, devoted heart and soul to his science, imparts to his students a portion of that interest in, and zeal for, original investigation, which are the real marks of a scientific spirit. Many of the chemical students at Heidelberg come, as with us, to study the science for the sake of its subsequent applications to Manufactures, Medicine, or Pharmacy—for all the German Druggists and Pharmaceutical Chemists are wisely compelled to attend a regular University course;—but many, probably a large fraction of the number, study the science for its own sake, most of these students intending to qualify themselves for the higher posts of scientific instruction in various countries. Amongst the companions of those who studied at Heidelberg with one of the Reporters, were men who are now making rising reputations in most of the German Universities, or in the various scientific institutions of France, Russia, Portugal, Great Britain and America.

The *Physiological Laboratory*, conducted by the celebrated philosopher, Helmholtz, is a novel and important feature in the Science Department in Heidelberg. A handsome and spacious building has re-



cently been erected for the use of the Professors of Physics and Physiology. This embraces Lecture-rooms, Laboratories, Rooms for Apparatus and Instruments, and for conducting special scientific investigations, besides dwelling-houses for the Professors and their families.

We were conducted over the admirably-kept Zoological collection by the chief Director, Prof. Pagenstecher. The yearly sum at his disposal for the maintenance and augmentation of the collection is 1,400 gulden; in round numbers, £120. Of this sum he devotes £50 to the acquisition of new specimens; £35 to the cost of preparations; £25 to glass and other materials, and £10 to heating, &c. Many of the more costly specimens have not been purchased, however, but formed the nucleus of the Museum. Still, by being always on the look-out, he often procures really valuable things for small sums. He told us, with great triumph, of his most recent acquisitions—a huge bison, from the Zoological Garden of Cologne, for £6, and a *Balaenoptera rostrata*, for £16.

The cases (which are fitted with *iron* not *wood*, for the larger specimens) alone have cost more than £1,000; this sum is not included in the annual estimate.

Prof. Pagenstecher insisted, with great animation, on the necessity of sufficient funds for maintaining and enlarging the collections. He told us he was always waging a fierce battle "einen grossen Kampf" with his preparations, though he managed to keep them under with the assistance of four or five young men who help him to dissect and prepare in his Laboratory.

In the winter half-year, Prof. Pagenstecher gives courses on *Special Zoology*, *Comparative Anatomy* and *Comparative Physiology*, with microscopic demonstrations; in the summer half-year, he gives *General Zoology* and *Palæontology*.

The cases in the Museum are freely open to the students, and a small catalogue is placed in each. All the year round a sort of Zoological Laboratory goes on for Zootomical practice.

Dr. Pagenstecher is Professor of the subjects enumerated, and Director of the Museum. On hearing of our present arrangement for teaching Natural History in Owens College, he expressed his surprise at the inadequacy of the provision. In his judgement, it is not possible to do with fewer than three professors at least, viz.:

Of Geology and Palæontology,  
 „ Zoology and Human Physiology,  
 „ Botany.

**CARLSRUHE.**—The Science Schools in Bonn, Göttingen, Berlin, Leipzig, and Heidelberg, are integral parts of those Universities; in form, indeed, they do not even constitute a distinct Faculty, being annexed to the Faculty of Arts. In Carlsruhe, however, exists an example of that important institution of modern Germany—the *Polytechnicum*.—The Polytechnicum may be defined as an institution for teaching, on the largest scale, all the branches of the Sciences of Experiment and Observation, and not only in their principles, but in their application to the several industrial Arts—these applications being not treated as illustrations of science merely, but rather regarded as the main subjects for instruction, for the sake of which systematic lectures were given on theoretic science.

The Polytechnic School at Carlsruhe, with that at Zürich, seemed to us to be very ably and successfully conducted, and to contrast favourably with some other institutions of the same kind, in the more highly scientific character of its teaching, both experimental and theoretic.

It is worth while briefly to describe the constitution of this important institution, with its 600 students.

In the original programme the School was declared to consist of *one* general and *seven* special departments. The general department, called the *Mathematical*, furnished instruction in Mathematics, in Natural Science, and in Modern Languages and Literature; and was viewed as preparatory to the special schools, and also as adapted for those who proposed to become teachers of Mathematics and Natural Science. The seven special schools were of (1) Civil Engineering; (2) Mechanical Engineering; (3) Architecture; (4) Forestry; (5) Manufacturing Chemistry; (6) Commercial Studies; (7) Civil Service (Postschule). This constitution is in the latest programme so far modified that (1) the General Department is no longer treated in form as introductory to the rest, though it still appears to be so virtually; and (2) the last two of the special departments enumerated above are omitted, while an Agricultural Department is added. The schools are, therefore, now seven; viz. :—

1. The School of Mathematics.
2. „ „ of Civil Engineering.
3. „ „ of Mechanical Engineering.
4. „ „ of Architecture.
5. „ „ of Chemistry.
6. „ „ of Forestry.
7. „ „ of Agriculture.



The teaching staff consists of the 24 Professors and 16 Assistant Lecturers and Laboratory Assistants. The appliances comprise five Laboratories (viz. : Chemical, Physical, Mineralogical, and for Forestry and Agriculture); a Library; and 12 different cabinets or collections. The department of Natural Philosophy appeared to us to be very ably conducted: as many as 120 students attend the lectures of Prof. Wiedemann, in the large theatre of the department: and the cabinets (which are the private property of the Grand Duke), are large and well arranged. In the Physical Laboratory were 14 students, who go through the course in groups of four; most of these become teachers of the subjects in Real-Schulen; some get important posts in large mechanical workshops.

**MUNICH.**—In Munich, as in Berlin, there are a University and a Polytechnic School side by side. The newly-founded Polytechnicum in Munich is to absorb the schools hitherto existing in Augsburg, Nuremberg and Würzburg. The buildings were not completed at the date of our visit.

Dr. Jolly, Professor of Experimental Physics in the University, in addition to his lectures, conducts a very important department called the Mathematico-Physical Seminary. There are at present about 10 or 12 in this department which, with the Physical Laboratory, is open to all who propose to become teachers of Physics in the Real-Schulen. Professor Jolly's method is much the same as that of Prof. Kirchhoff. He goes through each set of experiments once, and after that the students endeavour to perform them. When they fail to succeed, they consult the Professor or his Assistant. At the end of the semester there is a practical examination.

**ZÜRICH.**—In Zürich, also, there are both a University and a Polytechnic School; and although the University is a Cantonal and the School a Federal Institution, they are so far allied, that they share one building, and many students of the University are, at the same time, pupils in the School. The total cost to the State for the maintenance of the Polytechnic School is £12,000 per annum. The Professors of the two institutions, moreover, work to a certain degree in concert. For instance, Dr. Bolley is Professor of Chemistry in the School, and Dr. Städler, Professor of the same subject in the University. They have each a Laboratory; but Prof. Städler's is an Analytical, and Prof. Bolley's a Technical Laboratory. There are 42 students working in the former and 50 in the latter.

There is less freedom allowed to pupils of the School as to the classes to be attended. Definite courses are laid down: but, as at Owens College, relaxations are freely granted.

The most important department of the Polytechnic School is that of Mechanics and Engineering; there are also departments for Forestry and Agriculture, and an important department for teachers—a sort of Technological Seminary.

The Professor of *Technical or Applied Chemistry*, Dr. Bolley, lectures about three or four times weekly throughout the session. He makes four or five subdivisions;—as the Chemistry of Colour; of Heating and Lighting; of Materials; of Nourishment; of Agriculture. Before entering this class, the student is required to have attended a theoretical course and an elementary experimental course.

Dr. Zeuner, the Professor of Engineering, gives about 50 or 60 lectures yearly on the Mechanical Theory of Heat: and he lectures six times a week for two semesters, on the Theory of Machines. The character of his courses is very high and rigorous; he insists on a knowledge of the Differential Calculus as a condition of entering his classes. He proceeded to remark on the generally inadequate mathematical preparation of English students of engineering, and mentioned his conviction that Professor Rankine, for whose works he expressed an unbounded admiration, must find the sphere of his efficiency as a teacher seriously limited by reason of the want of due preparation on the part of his students.

The following extracts from the prospectus of the lectures in the engineering department of the Zürich school show how much more complete is the scheme of instruction there than has at present been found possible in England.

*B. Department of Civil Engineering. (Duration of course, 3½ years.)*

*1st year.*—Differential and Integral Calculus. Descriptive Geometry. Principles of Construction. Practice in Construction. Drawing. Experimental Physics. Experimental Chemistry.

*2nd year.*—Differential Equations. Technical Mechanics. Geometry of three dimensions. Perspective. Technical Geology. Topography. Drawing. Descriptive Mechanical Construction. Surveying.

*3rd year.*—Theoretical Mechanical Construction. Astronomy. Geodesy. Construction of Iron Bridges, Railways, and Iron Roofs. Drawing.

In addition to these courses there are similarly extensive programmes for (A) the department of Architecture, and (C) the department of Mechanical Engineering. The number of regular students in the



year 1867 was in these subjects: (A) Department of Architecture, 33; (B) Department of Civil Engineering, 103; (C) Department of Mechanical Engineering, 87.

*Freiberg Mining Academy, Saxony.*—This school, of world-wide reputation, offers many advantages over our Royal School of Mines in Jermyn-street, inasmuch as it is situated in the centre of a mining district, and combines complete courses of lectures on all the branches of science allied to mining, with practical instruction, not only in the working of mines (chiefly lead, copper, and silver), but also in the metallurgical processes, carried out on the large scale, employed in the extraction of the metals from their ores. This school has been famous ever since its foundation in 1766. Amongst the names of its Professors are found the most illustrious geologists, mineralogists, miners, and metallurgists of the time. The number of students at the school this last summer was 92, and of these, nearly half were young men from the United States, who come over in large numbers to study mining; indeed almost every nation is here represented. Foreigners pay fees amounting to £30 per annum, but the fees for Saxon students are almost nominal. We were told that there is at present no demand whatever for miners in Saxony, and that in consequence, the number of Saxon students has greatly diminished. The following list of lectures and practical courses delivered at Freiberg in the year 1865-6 gives an idea of the character and extent of the tuition:—

Subjects.	No. of Lectures per Week.	Subjects.	No. of Lectures per Week.
Mathematics, 1st Division .....	4	Mineralogy and Repetition Lecture .... {	4
Descriptive Geometry .....	4	Practical Mineralogy .....	1
Elementary Mechanics.....	4	Theoretical Crystallography.....	2
Mathematics, 2nd Division: and Mechanics	4	Geognosy and Repetition.....	1
Elementary Mechanics applied to Mines...	3	Palæontology .....	5
Construction of machines used in mining, )		Geology of Ores .....	1
1st course.....	2	Civil Engineering.....	2
" " " 2nd course...	4	Mining Engineering, 1st Division and Re-	3
Drawing .....	14	petition.....	5
Physics .....	4	Mining Engineering, 2nd Division and Re-	5
Theoretical Chemistry .....	4	petition.....	5
Practical Chemistry .....	4	Practical Assaying .....	15
<del>Practical Chemistry</del> .....	4	Practical Assaying in the Wet way.....	2
Analytical Chemistry .....	2	Blowpipe Assaying .....	6
General Underground Surveying.....	2	Mining Law .....	4
Practical Underground Surveying .....	2	Bookkeeping.....	2
Practice in such Surveying .....(Daily)...	9	French .....	4
General Metallurgy .....	4		
Metallurgy of Iron .....	2		
Assaying in the Dry way .....	1		

One day per week is left free from Lectures, to enable the pupils to visit the Mines and Smelting Works. All those who wish to pass the Government examination, and thus to qualify themselves for a post in the Saxon mines (which are all worked and owned by Government), must before they enter the Mining School, undergo a preliminary examination in general knowledge, and then devote 5 months to practical mining. A similar preliminary course in smelting is necessary before the Saxon student can be admitted to the lectures of the academy; these two practical courses, whilst obligatory on all regular or Government students, are open to all who wish to take advantage of them. After having gone through the academy, the Government student has to pass an examination arranged, according to the special part of the subject to which he devotes himself, (1) for miners; (2) for mining surveyors; (3) for machinists; (4) for smelters.

We were conducted by the veteran Mineralogist, Breithaupt, to see the unrivalled collection of minerals which he has brought together during his 50 years of successful labour at the academy. The whole of this, in many respects, the finest collection in the world has been made with the small annual grant of £45; but of course the mineralogical richness of the locality has greatly assisted the collector.

Connected, in a certain extent, with the Freiberg Academy is the recently-founded Free Mining School of Zwickau, established by the State chiefly for the education of the workmen engaged in the coal mines of Saxony. In this school the miners spend two days a week, working the rest of the time at their trade. The subjects taught are Mathematics, German Language, Mineralogy and Geology, and Practical Mining. Some of the most distinguished pupils of this school subsequently obtain free admission to the Freiberg Academy. The only institution analogous to this in our country appears to be the Bristol School for Miners; it is high time that steps were taken to do something for the education of the higher class of pitmen in our district, amongst whom a deplorable state of ignorance exists.



## II. The Provision made for the payment of Professors and Assistants, and for the maintenance and augmentation of Apparatus and Collections.

1. *Professors.*—The Professors ordinarii, at the German Universities and Polytechnic Schools, are servants of the State and, as such, all receive salaries from the Government, varying in amount from £50 to £400 per annum, according to the importance of the Chair and the standing of the Professor. In addition to this fixed stipend, a large portion or, in many cases, the whole of the fees falls to the Professor, and generally dwelling-houses are attached to the establishment, for the accommodation of the Professor and staff. In the case of several of the leading Professorships the houses are spacious and handsome and valued at least at £100 per annum.

2. *Skilled Assistants.*—Attached to every Professorship of Chemistry are several Assistantships. The assistants are chosen by the Professor from the most promising or best qualified students; they are also State servants, and receive salaries from Government amounting to from £40 to £60 per annum, with the addition of residence, with fire, &c. The duties of these Assistants are (1) to attend to the preparation for illustrating the experimental lectures of the professor; (2) to assist in the practical teaching in the Laboratory. For the first of these purposes, the services of one assistant are required; for the second, a number of assistants is required, in proportion to the number of students working. In Bonn and Berlin one assistant is appointed for every 12 or 13 students, whilst in other Laboratories a larger number of students are placed under each assistant. On the whole, we find that the average ratio of students to assistants is 20 to 1. In some cases, (as at Göttingen), the assistants are Professors (extraordinarii) in the University, and lecture on special subjects, as well as take a certain number of the beginners in the Laboratory altogether off the hands of the Professor.

3. *Fees.*—The fees both for Lectures and Laboratory practice are much lower than with us. This is, of course, explained by the fact that all the Science Schools are Government institutions. Thus, at Heidelberg the fee for the lectures on Chemistry (5 hours weekly, for from 4 to 5 months) is £1 14s. per "semester," whilst the Laboratory fee is £4 for working 6 days per week during the same period. It is, however, to be borne in mind that one great expense in working a Laboratory is the cost of apparatus and chemicals used by the students; this is specially paid for in the German universities by the State. Thus, at Göttingen, £140 per annum represents the materials used by students. In England the greater part of this charge falls upon the Professor. The scale of fees in the Chemical Department in Owens College is rather more than double this amount.

4. *Working Expenses.*—Through the kindness of the Professors of Chemistry at the several institutions which we visited, we are able to give the following statement of the expenses of working the Chemical Department, including all charges but the salaries of the Professors.

### Accommodation for Students.

	Laboratory.	Lectures.	Assistants.	Yearly Expenses.
1. Berlin University	60	200	5	£600 (insufficient)
2. Bonn	60	200	5	£600 (ditto)
3. Göttingen	80	150	4	£540
4. Leipzig	100	135	3	£600
5. Heidelberg	50	110	2	£350
6. Berlin, Polyt. School, } (two chairs), }	40	—	4	£600
7. Carlsruhe, Polyt. Sch.				
8. Zürich, Polyt. Sch., } (two chairs) }	60	66	4	£500

### III. Plans of Buildings, and their Cost.

We have obtained the following plans:—

1. General Ground Plan of Zürich Polytechnicum.
2. Leipzig Chemical Laboratory (pamphlet on).
3. Stuttgart Chemical Laboratory; ground plan.
4. Göttingen Chemical Laboratory
5. Carlsruhe " " ground plan and pamphlet.
6. Heidelberg " " pamphlet.
7. Bonn and Berlin; Hofmann's pamphlet.
8. Göttingen University Buildings; (photograph of ground plan).
9. Carlsruhe; general plan, in Koristka's book.
10. Zürich Chemical Laboratory, in Koristka's book.
11. Munich Polytechnicum; photographs of the working plans.



- The Cost of Building and Furnishing the Laboratories.*

- General Expenses of Education at Polytechnic Schools.*

2. *Zurich*.—109 lbs. of about 24. lbs. for the whole.

IV. *Rules of Studentship, in respect of Age, Preliminary Examinations, &c.*

The ordinary age for entrance at the German Universities is 18—the age at which the Gymnasium is in due course left. The time of study in the University extends over three years (six semesters); not a few students remain a fourth year, and such are the demands of the rapidly extending range of studies, that some of the most enlightened among German Academical authorities earnestly press the necessity of measures for enabling at least a large portion of the better students to spend a fifth year at the University.

The qualification for admission to the University is the possession of a testimonial

Such is the qualification for regular studentship. A considerable number of persons, however, not thus qualified, can attend single courses of lectures, but this attendance does not count towards the three years which qualify for the University degree, and for admission to professions and the public service. Changes are said to be impending in this respect; for the German Universities, like our own, are just now in a stage of transition. For State posts (the Civil Service), the old rule still applies, that no one who has not come to the University with the strict testimonial that he has satisfactorily gone through the previous Gymnasium course, can expect to enter the service of the Government.



The age for entrance into the Polytechnic Schools is one year younger than that for the Universities, viz., 17; the duration of study is the same, three years. Here, too, evidence of fitness is rigorously exacted of those who propose to enter as *regular students*, in the shape of an adequate school certificate, either from a Gymnasium, a Real-Gymnasium, or a Real-Schule—or, in default of that, an entrance examination must be passed. A much higher mathematical preparation is demanded, at least up to, and in some schools including, the differential calculus. Persons of all ages, however, and not possessing such qualification, are admitted freely and without examination, as *occasional students* in the several departments. Many of these occasional students were, we were informed, poorly prepared; but it was considered that the gain to such auditors, and to society through them, was very great; and that, whatever tendency might arise from the practice towards the lowering of the standard of instruction, could be guarded against by rigidly keeping up the standard of admission for regular students.

To many of the Polytechnica is attached a preliminary school, in which those who are not ripe for the full studies of the Polytechnicum can supply their deficiencies. The age for entrance to this *Vorschule* is sixteen.

The essential feature of the regulations which have been briefly described is this: that ordinarily, the *School*, the *University* or *Polytechnicum*, and the *Liberal Professions* (including the service of Government) stand in a close and recognised relation to each other. The Profession cannot be entered without evidence that the three years' University course has been satisfactorily gone through; nor is it allowed to matriculate at the University without the "leaving certificate," gained in the majority of cases after from 6 to 9 years' study in the Gymnasium, or a corresponding certificate of adequate fitness tested by rigorous examination. This system, of course, presupposes such an organization of schools and colleges, and such reciprocal relations between them, as do not—and, probably, could not—exist in England.

V. *Relations existing between the Universities proper and the Polytechnic Institutions; and again between these on the one hand and schools, whether 'Gymnasias' or 'Real-Schulen,' on the other.—The attitude of the scientific towards the old classical culture.*

We have had occasion to refer to four kinds of institutions—Universities; Polytechnic Institutions (a sort of Science Universities); Gymnasias (*Anglice*: Grammar Schools); and Real-Gymnasias (High Schools of Science);—these last being newly established schools, designed to prepare boys especially for the Polytechnica.

It appeared to us that very great evils must result from this tendency to multiply institutions—a tendency springing, probably, from the difficulty of modifying old institutions to meet new wants. In the first place, there is room to fear that a due supply of thoroughly good teachers, especially in science—at least in the higher positions—cannot be secured for institutions perpetually growing in number; while, on the other hand, a great waste of power is caused, where such institutions exist side by side, as many of the Professorships, being common to Universities and Polytechnic Schools, are thus twice represented. It was alleged that this evil is already showing itself in Germany; and it is probable that in England the danger would be greater still.

Again, serious harm must come from the tendency which this separation of the Polytechnic School from the University has to foster the narrow one-sidedness already so strong in the extreme partisans of the one and the other group of studies. The Universities would suffer by the weakening in them of those branches of pure and applied science which have always been and must continue to be studied there. The Polytechnic Schools would suffer (and already do suffer) from the tendency, thus encouraged, to neglect the educational aspects of science in its practical applications. How great the gain has been to all branches of the liberal arts and sciences from their alliance in Universities, the history of Universities from their first foundation abundantly shows: and it is difficult to see any sufficient reason why the applied sciences in their professional aspect should not have their proper place in the organization of our Universities, exactly as Theology, Law, and Medicine, have long had their place,—to the great advantage both of these studies themselves and of the non-professional studies with which they have been brought into contact.

Prof. Magnus, the eminent Professor of Natural Philosophy at Berlin, already detects signs that the new-born zeal for teaching science in its application to the practical arts, is encroaching on the domain of science proper, and that it will thus deteriorate science without, at the same time, advancing industry. The true work of institutions, founded with the special aim of fostering the industrial arts, should be to insist on teaching *principles* systematically, and not in their isolated applications. To treat of the applications of science is, of course, necessary, even for the sake of science itself; and under certain circumstances, some of these applications may wisely be more dwelt on than others; but this is quite a different thing from pretending to teach as *science* detached fragments of science in their application to this or that art.

Many of the most experienced and sagacious of our advisers, while themselves pointing out this danger, saw great difficulties in the way of the one obvious remedy for it—the absorption, namely, in many



cases, at all events, of the Polytechnicum in the University. The chief of these difficulties arises out of the ancient tradition of the German Universities—the much boasted *Lern-und Lehr-Freiheit*—by which the amplest license is left to Professors, as to what they shall teach, and to students, as to what they shall learn: whereas, in the Polytechnica, it is found necessary to lay down a much more definite course of study, and to exact attendance upon it.

This is, no doubt, a serious obstacle in the way of the proposed amalgamation in Germany, but in England, and especially in a College of recent foundation, the difficulty would not arise at all. Apart from questions of tradition and historical routine, there can be no reason why students of applied science, led to the study by their probable destination to manufacturing industry, should not study systematic science in the same class-rooms with other students of the same subject: and if such students require minute practical and experimental instruction, there is no reason why they should not obtain this in physical and mechanical, as they do already in chemical, Laboratories. In such a technical department, the future teachers of science and leaders of manufacturing industry would be trained in the application of science to the most important branches of art and manufacture—in so far, that is, as these are fit subjects for academical treatment; in so far as they are not, they are better left to the workshop.

*Schools.*—Although we were not directly instructed to inquire into questions connected with secondary schools, we found it impossible wholly to pass them by. We were informed that the relations between schools and the higher institutions (whether Universities or Polytechnica) were being warmly debated in Germany, and that great changes were probably impending.

At present, as has been said, no one can be regularly inscribed as a University student without the “leaving certificate” from a Gymnasium, or a certificate showing a corresponding degree of preparation; and the same is true of the ordinary students in Polytechnica, except that there the number of occasional students who attend under dispensation is much larger. None of those whose opinions will probably affect the decision arrived at appear to contemplate any material relaxation of this rule, so far as the principle is concerned of rigorously exacting adequate fitness for entering with profit on the higher course of instruction. The demand for change comes in the main from the Directors of the Polytechnic Schools, and others who are chiefly interested in promoting scientific education in its application to manufacturing industry. These say that the success of the *Polytechnica* depends on the existence of good schools in which boys can be prepared; and they complain that the *Gymnasien* are too exclusively classical, that they do not teach mathematics well, or to a sufficiently high point, and that natural science is either altogether neglected, or poorly taught. The *Real-Schulen*, on the other hand, they say, are, for the most part, schools of an inferior order, not so well officered, and holding much lower rank in public estimation. They advocate, as the only sufficient remedy, the general establishment of a new class of schools, to be called *Real-Gymnasien*, to take equal rank with the old *Gymnasien*, and in which pure and applied science shall have the same pre-eminence which Classics enjoy under the present system.

That there is great ground for the complaints made cannot be doubted. It is not, however, so clear that the remedy proposed is either *necessary* or likely to be really *effective*.

It is not likely to be really effective. The tendency, already noticed in some of the new science institutions for older students, to merge the strictly educational and disciplinary aspects of science in its practical applications could not but be strengthened by the complete separation of the two lines of culture in the schools. In fact, it is generally admitted that the *Real-Schulen*, which have been in thorough operation for about half a century, have not well fulfilled the hopes entertained of them, and the experience so far supplied by the few *Real-Gymnasien*, the general introduction of which is demanded by some, does not, in the opinion of many most competent witnesses, hold out promise of greater success.

Again, we believe that it is to the full as important in the interests of those who are to enter the Universities, that a much more thorough discipline in Mathematics, and even in the Elements of Physics, should be introduced into the old *Gymnasien*, as that the future students of the Polytechnica should receive some classical culture with their more extended training in mathematics and physical science. Hence it follows that the establishment of the proposed exclusively scientific *Gymnasien*, undesirable in itself, is not necessary for the purposes aimed at. The great preponderance of authority, with which our own conviction agrees, we found to be against the introduction of the new schools, and in favour of such a modification of the existing *Gymnasien* as that, while the training should be identical for all boys up to a certain stage, in the two highest classes a *bifurcation* should be made,—boys designed for the University entering what we may call the *Classics side*, and boys designed for the Polytechnic entering the *Science side*. The teaching in the lower and middle parts of the school would, at the same time, be so modified, that both sets of boys would get some of the old and some of the new culture. What the character of this modification should be we will state in the words of Prof. Köchly, of Heidelberg, the eminent Greek Scholar and Director of the Philological Seminary in that University, by whom the proposed solution was explained to one of us:—(1) a teaching of



Classics, not less thorough, but with some degree of limitation; (2) a much more extended development of Mathematics; (3) the introduction of Natural Science, in its essential and characteristic principles; (4), Systematic Instruction in Modern Languages.

Such a system is now under consideration in some parts of Germany. Under it the newly-introduced *Real-Gymnasium*, or High Science School, would be absorbed in the old Gymnasium, or Grammar School, and on the other hand, the *Real-Schule* would, probably, be amalgamated with the *Ober-Burger-Schule*. To do away with this incessant multiplication of schools would itself be a great gain, and many of our advisers were strongly in favour of the consolidation.

We have already quoted the emphatic opinion of an eminent classical scholar (Prof. Köchly), in favour of the introduction into Grammar Schools of more mathematics and some physical science, with a consequent limitation of the amount of the classical work. On so important a question, it is worth while to give the not less emphatic opinion of some eminent men of science, in favour of the retention of much of the old classical discipline in the school training of those who are to devote themselves to the study of science.

Prof. Hofmann sees the best safeguard against the vulgarizing of science, when taught with too special a regard to its applications in a radically sound school-training; and from this point of view he believes the old classical Gymnasium system to be of inestimable value. In scores of instances he has seen youths, who have come to his Chemistry class (in the University of Berlin), with scarcely a knowledge of the name, but who had been well trained in a Gymnasium, and who, after a year, have completely outstripped comrades who have brought with them from school a considerable amount of knowledge (so called) of the elements of Chemistry.

Prof. Dove (a no less celebrated name) does not attach much value to the movement for founding *Real-Gymnasias* of equal rank with the ordinary Gymnasias. He protests against the separation, and thinks it certain to be attended by inferior teaching and discipline in the new schools.

Prof. Kopp, of Heidelberg (Professor of Chemistry), thinks that the regular Gymnasiast education fits a man well for subsequent scientific work at the University. Men thus trained soon outstrip those who come up with an indifferent training from a Real or Polytechnic School. The best preparation at school for a scientific education is a thorough mathematical training, up to the Differential Calculus, giving exactitude and facility of work to the pupil.

To these weighty opinions from men of the highest scientific eminence we may add the judgement of Prof. Trendelenburg, perhaps the most eminent of living logicians. Dr. Trendelenburg, formerly Rector of the University of Berlin, has been a member of a small commission of inquiry on this very head. He doubts the wisdom of the change recommended by some, of opening the University to scholars from the Real schools, and believes that the Gymnasium can be so modified as to meet all the real requirements of the new studies. He informed us that Mitscherlich, Prof. Hofmann's predecessor in the Chair of Chemistry in Berlin, had expressed to him the same conviction as that of Dr. Hofmann—that the Gymnasium training was superior even for those who are to be science students; and this judgment Dr. Trendelenburg declared that he himself shared.

Most striking evidence of this alleged superiority of the old to the new schools, in method and discipline, is furnished by the significant fact told us by Prof. Kübler, Director of the Wilhelm's Gymnasium (the second in size and importance in Berlin), that in Real schools not more than 1 per cent of the boys stay long enough to reach the first class, while in the Gymnasium as many as 10 per cent reach that stage, and he did not think that there was any such difference in the social rank of the boys as to account for this.

On the other side, we heard from Dr. Reuleaux, Director of the Gewerbe-Akademie (or Polytechnic School) of Berlin, and from Prof. Zeuner, of the Polytechnic School at Zurich, an opinion that the Real-Gymnasias, or some corresponding scientific High Schools, were desirable. Prof. Zeuner, however, allowed that the *bifurcation* system in the higher classes of the Gymnasium would, if fairly worked, meet the requirements of the Polytechnic Institutions.

But the weightiest authority in favour of the two sets of schools was that of Prof. Helmholtz, the very eminent Physicist and Physiologist of Heidelberg. His reason is a striking one—"Philological culture has an ill effect on those who are to devote themselves to science: the Philologist is too much dependent on authority and books; he cannot observe for himself, or rely upon his own conclusions, and having only been accustomed to consider the laws of Grammar, all of which have their exceptions, he cannot understand the inviolable character of physical laws. Hence," he concluded, "it is a great point to have in the foundation, on equal terms, of complete academic institutions for science, a counteraction to the tendency of classical men to lean on authority alone."

To this thoughtful remark of Prof. Helmholtz the greatest respect is due; but it appears to us that from our point of view it tells directly *against* the establishment of two sets of schools. The object being to arrive at the best system of academic culture, and of school preparation for it, it is surely wise neither to



deprive the philological boys of the counteraction supplied by science for the besetting sins of an exclusively classical training, nor to deprive the young students of science of the advantages which may surely be allowed to belong to some measure of the discipline of letters. Indeed, his objection vanishes if the classical Schools are remodelled in the way proposed, and if equal honour is secured to both sides.

It should be added that the bifurcation system has been tried, with excellent results, in more schools than one. Conspicuous instances of its success are the Wilhelm's Gymnasium, which we visited in Berlin, and the Friedrich Wilhelm's Gymnasium at Cologne, described by Mr. Matthew Arnold.

#### VI. *Relations existing between State Governments and Academical Bodies.*

In the German Universities, as we have already said, the Professors are servants of the State. Respect, however, on the part of the Governments for the dignity of the Universities, and a genuine concern for their efficiency, combined with the force of public opinion, prevent, for the most part, any practical interference with the freedom of the Professors. The mode of appointment, at least in Prussia, is as follows:—When a vacancy has arisen, the Professors of Faculty are invited to name the most suitable person to fill the vacant chair. The Minister of Education is not bound to follow the advice of the Faculty, but he generally does so: in case, however, of any difficulty as to the appointment, either on the part of the Minister or on the part of the person designated, the Faculty is invited to propose a second, or even a third. Once appointed, the Professor, in concert of course with his colleagues, selects his own subjects and hours of lecture. There is not even any definite obligation on him as to the precise number of his lectures; but public opinion, and his oath to do all that can promote the success of his office, are ordinarily found sufficient. In Germany this system on the whole works well. The Professors who form the Faculty exercise their function with the deepest sense of their responsibility in doing so; and so well is this understood, that this formal invitation to a person to take a vacant chair (the *Ruf*, as it is called), even though, for whatever reasons, the appointment be not made, is treated as an honourable testimony to worth and learning, and as a rule receives some acknowledgement on the part of the State, either in dignity or stipend. In Germany this system exists under the most favourable conditions. In the course of centuries satisfactory mutual relations between Governments and Universities have had time to form themselves, and the numerous Universities are eager candidates for the services of the most distinguished Professors.

#### VII. *Seminaria, &c.*

Our report would be imperfect as regards the object of this inquiry without some reference to the *Seminarium*—a characteristic institution of the German Universities, which we believe might in some form be introduced with great benefit into this country. The ordinary lectures of the Professors being continuous discourses and the Students being *hearers* only, and not subject to any oversight as to attendance and industry, it is found that this system does not suffice for the training of those who are themselves to be teachers. To meet this want the *Seminarium* was established. A limited number of students, whose merit and adequate preparation are ascertained, are in the Seminary drilled in the manner usual in College lecture rooms in England, but with the special object of qualifying them for original investigation and for the higher teaching posts. The most distinguished Professors of the University conduct these classes; admission to them is frequently regarded as a high privilege; and regular attendance and due performance of the exercises given out follow as a matter of course. There are often two sections, an upper and a lower; and the members of the upper section take part in the instruction of those of the lower. The seminaries are state foundations, and to the regular members (whose number is small) the fees are very low or are even entirely remitted, and to the more distinguished students small exhibitions are given. *Seminaria*, at first limited to Theology and Philology, are formed for most of the leading branches of study; as, for instance, the Philological Seminarium, the Mathematico-physical Seminarium, the Historical Seminarium, &c. It is obvious that the Chemical and Physical Laboratories also perform the functions of the Seminarium. At Owens College this system is virtually in operation as far as is possible with the limited teaching power which we at present possess.

We have had occasion to mention many characteristics of the German Universities which appeared worthy of imitation by us. It is right to notice that there are two institutions of our own Universities which some of the most enlightened Professors of Germany earnestly desire to introduce among themselves; (1) the provision of Exhibitions or Scholarships, to enable young men of merit and promise to go through a longer course of study, and (2) the provision of Halls of Residence in which those students who might seek such accommodation could live and carry on their studies under fitting superintendence. Authorities as eminent as Prof. Trendelenburg, of Berlin, Dr. Döllinger, of Munich, and Prof. von Sybel, of Bonn, agree in wishing to see these English institutions grafted on the University system of Germany. Professor Trendelenburg would warmly approve of a system under which a common ground of instruction



in literature and science should be provided for members of all religious confessions, while in Halls provision should be made for Theology and the studies subordinate to it. Such provision exists at Berlin for Roman Catholic and Protestant students of Theology; and he thinks that lay students should have corresponding provision made for them, though of course none should be obliged to resort to it. "If any one," says Prof. von Sybel,\* "is inclined to reject such a proposition as an innovation opposed to the spirit of the age, let him first behold with his own eyes how much there is in the outer life of our students injurious to health and physical strength, and therefore injurious to industry and mental vigour, and then let him judge what benefits judicious measures in this direction would bring with them." The arrangement contemplated by Prof. von Sybel is probably such as that desired by many in connection with Owens College,—the foundation, whether by individual benevolence or by the contributions of any religious body, of Halls (in close alliance but not organically connected with the academic system) which would offer convenient residences, under fitting tutorial superintendence.

\* Die Deutschen und die Auswärtigen Universitäten, p. 30.

#### VIII. *Conclusions.*

The general conclusions to which we have arrived are as follows:—

1. That the thorough efficiency of an institution such as Owens College, in its proposed extension, demands a sub-division of each leading subject more complete than is usual in England, and a provision for the scientific departments far more elaborate.

2. That consequently, great as are the objections to complete dependence on the state as witnessed on the continent, some measure of aid from the national exchequer, at least in the case of new foundations, and especially for Schools of Science, becomes almost a necessity. Such aid would be further justified by the means which institutions of the kind would possess of training science teachers of a high class for primary as well as secondary schools.

3. That in order to ensure the lasting efficiency of such institutions as Owens College, it is important strictly to maintain their University character and organisation, and this with a view to the interests not only of abstract science, but also of its applications to the Arts and Manufactures.

4. That the acknowledged success of the German University system, and of the Polytechnica, is intimately bound up with the strict preliminary training of the old Gymnasias, and other secondary schools; and in like manner in England the permanent and widespread usefulness of institutions for the higher education will mainly depend on a corresponding amount of efficiency in secondary schools.

J. G. GREENWOOD.

H. E. ROSCOE.

OWENS COLLEGE, *December, 1868.*



Cornell College Extension.

# REPORT

TO THE

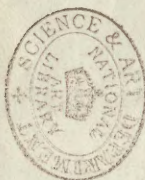
EXTENSION COMMITTEE

OF THE

INSPECTION OF THE

UNIVERSITIES AND SCIENCE SCHOOLS

OF GERMANY.



(Printed for Private Circulation.)

1868.

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